EFFECT OF AGE ON THE SENSITIVITY OF UPPER AIRWAY REFLEXES

R. J. ERSKINE, P. J. MURPHY, J. A. LANGTON AND G. SMITH

SUMMARY
We have recorded the threshold concentration of inhaled ammonia vapour required to elicit reflex glottic closure (NH₃TR) in 102 healthy, non-smoking volunteers (39 female) aged 17–96 yr in order to assess the effect of age upon upper airway reflex sensitivity. A single measurement of sensitivity was made in each subject using a system delivering small concentrations of ammonia vapour for single intermittent breaths to the upper airway and recording glottic closure using an inspiratory pneumotachograph. We found a strong positive correlation between age and NH₃TR, indicating a decrease in upper airway reflex sensitivity with increasing age. (Br. J. Anaesth. 1993; 70: 574-575)

KEY WORDS
Age factors. Airway: reflex sensitivity.

Reflex activity is thought to diminish with advancing age. Laryngeal reflexes in the elderly appear to be less active, both during induction of anaesthesia and in the recovery room, compared with the younger patient—suggesting that protection of the airway may be impaired in the elderly [1].

The protective reflex of the larynx is evoked by stimulation of receptors thought to be located in the hypopharynx and larynx. With concentrations of irritant vapour smaller than that required to produce cough, the response is glottic closure, and a brief pause in inspiration. The upper airway is sensitive to both chemical and mechanical stimuli, the former being both quantifiable and reproducible [2].

Using equipment described previously [2], we have measured the threshold concentration of ammonia vapour (NH₃TR) required to stimulate reflex glottic closure in patients. Previous workers [3] found a six-fold increase in the concentration of inhaled ammonia vapour required to produce a reflex stop in inspiration in patients between the second and eighth and ninth decades. However, that study population contained a large proportion of smokers and our early work [4] has shown that smokers have considerably more sensitive upper airway reflexes than non-smokers.

The aim of this study was to measure NH₃TR in non-smokers over a broad age range in order to assess the effect of age alone on upper airway reflex sensitivity.

METHODS AND RESULTS
After obtaining Ethics Committee approval and informed subject consent, we studied 102 healthy, non-smoking subjects aged 17–96 yr. The majority (85) were preoperative elective surgical patients, the remainder being members of our department, nursing staff and nine patients from geriatric wards. We excluded those with mental or neurological impairment, chronic bronchitis and asthma, a history of upper respiratory tract infection in the past month, and those receiving sedative medication. Two subjects had smoked in the past: one stopped 25 yr previously, the other stopped 4 weeks before the study.

Measurements were made either in our laboratory or on the ward, using the same portable equipment. A single measurement of NH₃TR was made in each subject, using the method described previously [2]. We have found that no significant difference exists between repeated measures made on the same day and on separate days in the same individual [2].

NH₃TR was plotted against age for each subject (fig. 1); there was an increase in NH₃TR with advancing age. The correlation coefficient was calculated as +0.85, indicating a strong positive correlation between age and NH₃TR.

Mean NH₃TR for the age group 21–30 yr (n = 14) was 571 (SEM 41.5) p.p.m., compared with a value of 1791 (52) p.p.m. for the group aged 86–95 yr (n = 14).

COMMENT
Whilst loss of peripheral reflexes in the elderly may be of little anaesthetic significance, the reduction in the sensitivity of upper airway reflexes associated with age may be important, particularly after anaesthesia or sedation, when full airway protection may be delayed, with a consequent increased risk of aspiration [1].

In 1960, Pontoppidan and Beecher carried out a similar study using ammonia vapour [3]. They...
assessed 103 subjects aged 15–84 yr and found that
the threshold increased more than six-fold from
the second to the eighth and ninth decades, and that
the between-subject variability in sensitivity increased
with age. However, we have identified several factors
that may have produced inaccuracies.

First, their breathing system contained a large
canister into which the ammonia vapour was
injected. This could have allowed streaming to occur
and, depending upon inspiratory flow and the timing
of inspiration, could have produced a variable
concentration of ammonia. Also, depending upon
the tidal volume and inspiratory flow rate of the
subject, the stimulus may have been presented to
the upper airway at differing times during the ventilatory
cycle. The authors stated that the actual concentra-
tion of inhaled ammonia was unknown, but was
assumed to be directly proportional to the absolute
amount of ammonia used. Furthermore, seven
subjects failed to respond to the maximum delivered
stimulus of ammonia. Second, they used a metabolic
spirometer to record the change in inspiratory flow,
and not a pneumotachograph. Finally, their popu-
lation contained a high proportion of smokers (85 %),
although this varied between 33 % in the 70–79 yr
and 83 % in the 50–59 yr group, but they could
find no consistent influence of smoking upon airway
irritability. In contrast, we have found that those
subjects who regularly smoke more than 15 cigarettes
per day have a significantly smaller NH3 TR than
non-smokers of the same age [4], indicating that
smokers have more sensitive upper airway reflexes.
Therefore, in this study we have excluded smokers.

In essence, our results support Pontoppidan and
Beecher’s work, indicating an increase in NH3 TR
with increasing age, but we found the mean NH3 TR
increased only three-fold from the third to the ninth
decades—a change which was only 50 % of
that of their study. In addition, we found no increase
in between subject variability in NH3 TR with age
and, in general, our results were more tightly
clustered in each age group. These differences
between the earlier study and ours, in particular
regarding distinction between smokers and non-
smokers, may be explained by the improved design
of our system, which delivers a more constant,
known concentration of ammonia vapour [2].

The cause of this increased threshold in the elderly
is unknown. The irritant receptors in the upper
airway are thought to consist of free nerve endings
ramifying among epithelial cells; they have been
classified as type 1, rapidly adapting receptors,
although no nervous end-organ has been identified
histologically. Increasing age is associated with a
reduction in the population of nerve endings and
this, combined with the thickening that occurs in the
mucosa of the upper airway thus reducing penetra-
tion of noxious chemicals, may lead to an increase
in stimulation threshold. A decrease in amplitude
of electrical potentials in pulmonary afferent vagal
fibres with age (possibly caused by degenerative
changes in sensory neurones of the Nodose (Vagal)
ganglion) has been described in humans [5]. A
similar mechanism may affect fibres from the
superior laryngeal nerve. A histological study of age-
related changes in the rat superior laryngeal nerve
has demonstrated segmental demyelination and
axonal degeneration in the elderly group and other
ultrastructural changes associated with complete
fibre dysfunction [6]. Several of these changes
resemble those seen in aged human peripheral
nerves, in which a decrease in fibre numbers is also
a significant feature [5].

It is not possible to infer directly from our results
that a progressively greater NH3 TR associated with
advancing age implies a loss of protective reflexes
and consequent increased risk of aspiration. How-
however, the increased reflex stimulus threshold in the
elderly may be a contributory factor, and emphasizes
the need for increased vigilance during recovery
from anaesthesia or sedation.

ACKNOWLEDGEMENTS
This study was supported by a grant from the Trent Regional
Health Authority and an equipment grant from The Association
of Anaesthetists of Great Britain and Ireland.

REFERENCES
1. Davenport HT. Anaesthesia for the geriatric patient.
2. Langton JA, Murphy PJ, Barker P, Key A, Smith G.
Measurement of the sensitivity of upper airway reflexes.
3. Pontoppidan H, Beecher HK. Progressive loss of protective
reflexes in the airway with the advance of age. Journal of the
4. Erskine RJ, Murphy PJ, Langton JA, Smith G. Upper airway
reactivity in smokers and non-smokers. Tenax World Congress
5. Brizee KR, Ordy JM. Effects of age on visceral afferent
components of the autonomic nervous system. In: Brizee KR,
Ordy JM, eds. Sensory Systems and Communication in the
Elderly, Aging, Vol. 10. New York: Raven press, 1979,
58–59.
6. Rosenberg SI, Malmgren LT, Woo P. Age-related changes in
the internal branch of the rat superior laryngeal nerve.
Archives of Otolaryngology Head and Neck Surgery 1989;
115: 78–86.